A Simple Robust Digital Image Watermarking against Salt and Pepper Noise using Repetition Codes

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Abstract—**In this paper a robust, spatial domain watermarking scheme using simple error control coding technique is proposed. The idea of this scheme is to embed an encoded watermark using (5,1) repetition code inside the cover image pixels by LSB (Least Significant Bit) embedding technique. The proposed algorithm is simple, more robust against Salt and Pepper Noise than LSB only watermarking techniques. In this paper comparison is made between embedding different watermark encoding schemes such as (7, 4) Hamming code, (3, 1) repetition code, (5,1) repetition code and without encoding for different noise density of salt and pepper noise. Result shows watermark encoding scheme using (5,1) repetition code provides better robustness towards random error compared to other said scheme, without much degradation in cover image.**

Index Terms—**LSB Watermarking, Repetition code, Hamming code, Salt and Pepper noise**

I. Introduction

In recent years the growth of Internet and multimedia systems has created the need of the copyright protection for various digital medium (Ex: images, audio, video, etc.). To protect the digital medium (Images) from illegal access and unauthorized modification Digital Image watermarking is used. It is a branch of information hiding, which hides ownership information inside the cover image. Watermarking can be broadly classified in to visible or invisible watermarking [1, 2]. Generally invisible watermarking is used in digital multimedia communication systems.

Watermark embedding can be in spatial or transformed domain. In spatial domain watermarking, watermark bits directly alter the cover image pixels. Where as in transformed domain watermarking cover image is transformed into frequency domain and then watermark bits are embedded [3]. Once watermark embedding is done watermarked images are undergone wide verity of distortion during processing, transmission, storage, compression and reproduction, which may result in visual quality degradation of the watermarked image [4]. This degradation in turn affects the visual quality of the watermark. It may be necessary for identification of ownership.

This paper discusses how distortion in watermark can be reduced and robustness against salt and pepper noise can be improved by simple watermarking and error control coding scheme. The rest of the paper is organized as follows. In next section related works are discussed. Section III describes requirements of watermarking system. Basic concepts of LSB watermarking, error control coding techniques and salt and pepper noise are discussed in section 1V. Proposed scheme is described in section V. In section VI Performance analysis is illustrated. Conclusions are discussed in section VII.

II. Related Works

In spatial domain, LSB substitution technique[5,6] can be used to embed the secret data in cover image. In LSB technique 1 bit of secret message replaces the least significant bit of cover image pixel. LSB technique is relatively simple and has low computational complexity [3].

A spiral based LSB approach for hiding message in images was proposed in [16]. They used LSB substitution technique to embed the watermark and order of insertion of watermark based on spiral substitution algorithm. In [13] 3rd and 4th LSB Substitution technique was proposed. They used 3rd and 4th LSB bit position of cover image pixel to embed two watermark bits. This technique may increase the storage capacity to accommodate the watermark bits, but results decrease in perceptual quality of watermarked image. A Reversible watermarking technique in spatial domain with error control coding technique was discussed in [12]. They initially encrypted the watermark and then encoded using error control coding technique. This encoded watermark was embedded in the cover image using reversible watermarking technique. Results show that improvement in robustness by encoding watermark using (15,5) BCH code compared to (7,4) Hamming code, (15,3) and (15,5) RS codes in a random error channel where watermarked image was corrupted by Salt and pepper noise. But Watermark encoding and decoding processes are complex. In [15] application of channel coding in the spatial domain watermarking system for copyright protection of images was proposed. They used turbo code to encode the binary watermark and embedded in cover image directly by altering the pixel values. The scheme shows using turbo code provides better performance than encoding watermark using BCH code. A variable block size based adaptive watermarking in spatial domain was proposed [14]. In this scheme cover image was divided into blocks, and then watermark bit was embedded by altering the brightness value of the pixel. This may affect the perceptibility of the watermarked image.

In this paper LSB replacement technique is used for embedding process and simple (n,1) repetition code where n=3 and 5 are used for encoding the watermark. Robustness of watermark embedding scheme against salt and pepper noise is investigated for the cases

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1. Without encoding of watermark.
2. With (7,4) Hamming code for encoding watermark and
3. With proposed (3,1) and (5,1) repetition code for encoding watermark.

III. REQUIREMENTS OF WATERMARKING SYSTEM

In this section, a number of watermarking system requirements as well as the tradeoffs among them are discussed.

Imperceptibility: The imperceptibility refers to the perceptual transparency of the watermark in the cover image. Ideally, no perceptible difference between the watermarked and original image should exist.

Robustness: Robustness means ability to detect the watermark in presence of common signal or image processing attacks such as salt and pepper noise, Gaussian noise, channel noise, compression, geometrical attacks (cropping, scaling, rotation etc.), Random channel error etc.

Capacity: Watermarking capacity refers to the amount of watermark information that can be embedded into a host image. Higher capacity implies that, more information can be embedded, but imperceptibility is poor.

Blind watermarking: Original cover image or watermark is not used in the process of watermark extraction.

Implementation Cost: Watermarking algorithm should be simple, so that hardware implementation cost will reduce.

Processing Speed: Computation complexity of watermarking scheme decides processing speed of the algorithm so that time delay will reduce.

IV. WATERMARKING SCHEME

The scheme aims to embed the encoded binary text patterned watermark using simple error control coding scheme such as repetition code inside the cover image pixel I(x, y) using LSB watermarking technique. Encoded watermark is extracted simply collecting LSB bits from watermarked image I'(x,y). Repetition decoding is applied to get back the original watermark W(m,n). The scheme is shown in the Fig. 1a and 1b.

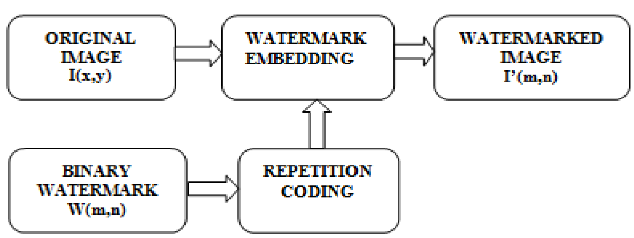

Figure 1a. Encoded Watermark Embedding

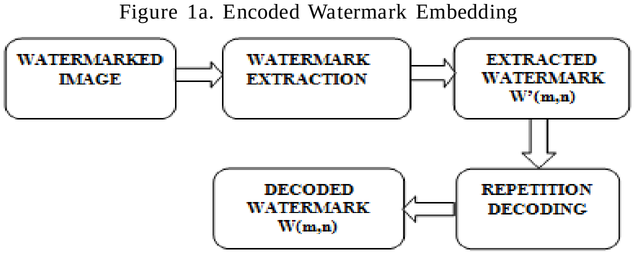

Figure 1b. Watermark Extraction

A. LSB Watermarking Scheme

The LSB watermarking is a simple replacement technique used to embed watermark information in the cover image [5, 6]. In this technique if cover image is of 8-bit grayscale image and watermark is binary data then 1-bit of watermark replaces the LSB of cover image pixel as shown in the Table-I.For Ex: If cover image pixel is 153(10011001) and watermark bit is '0' then change in pixel value is 152(10011000). So by this technique each LSB of the image pixel stores 1bit of the watermark. If cover image is 256X256 pixels, then it can store 65536 bits or 8192bytes of watermark. Changing the LSB of a pixel results in small changes in the intensity of image. These changes cannot be perceived by the human visual system. However, a passive attacker can easily extract the changed bits, since they can be recovered by very simple operation. To make watermark immune to noise and security to passive attack one can insert watermark in higher order bits of the cover image. This may improve robustness and security, but distorts host image at large scale i.e perceptibility of the watermarked image decreases. For example if cover image pixel value is 153(10011001) and watermark bit '0' is inserted in to 4th LSB bit of cover image pixel value change is 145 (10010001) if watermark bit is '1' then no change in the pixel value. The change per pixel value is '8' or no change. Immunity against passive attack can be obtained by encrypting the watermark image before embedding [12].

TABLE I. WATERMARK EMBEDDING USING LSB TECHNIQUE

Cover Image LSB bit	Watermark Bit	Change in Cover image Pixel LSB bit after embedding Watermark
0	0	No change
1	0	1 to 0
0	1	0 to 1
1	1	No change

B. Error Control Coding For Watermark Information

Transmission and storage may cause random error because of salt and pepper noise. To improve immunity against this noise one can encode the watermark with error control coding scheme. Many simple and complex error control coding schemes are available [11]. Simple scheme is one in which computational complexity is less. In this paper Hamming code and repetition code are used for error control coding and LSB technique is used to embed encoded wate rmark. The performance of these schemes in presence of salt and pepper noise is investigated for different noise densities.

Hamming Codes

Binary Hamming codes are class of linear block codes with single error correcting capability. In an (n,k) Hamming code where k is the number of bits in message word, n is the number of bits in the corresponding encoded word with n>k and (n-k) are the number of check bits. Hamming codes are characterized by

$$n = 2^m - 1$$
$$k = 2^m - 1 - m$$

Where m=2, 3, 4, . . .

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In this paper m=3 is chosen and corresponding code is (7,4) block code. In the encoding scheme 4 bits of watermark is encoded into block of 7 bits. A (7,4) systematic hamming code is given in [11] is characterized by generator matrix G and is of the form given below.

$$G = [I_{4x4} : P_{4X3}] \tag{1}$$

Where sub matrices I_{4X4} is 4X4 Identity matrix and P_{4X3} is 4X3 parity check matrix.
One possible G matrix is (2)

$$G = \begin{bmatrix} 1\,0\,0\,0\,1\,0\,1 \\ 0\,1\,0\,0\,1\,1\,1 \\ 0\,0\,1\,0\,1\,1\,0 \\ 0\,0\,0\,1\,0\,1\,1 \end{bmatrix} \tag{2}$$

The Encoded word V is given by

$$V_{1x7} = [d_{1X4}] \text{ X } [G_{4X7}] \tag{3}$$

Where d is message word
The set of all message words and corresponding code words determined using (3) is given in Table II

TABLE II. SET OF ALL POSSIBLE 4-BIT MESSAGES AND CORRESPONDING7-BIT ENCODED WORD

Message Word d	Encoded Word V
0 0 0 0	0 0 0 0 0 0 0
0 0 0 1	0 0 0 1 0 1 1
0 0 1 0	0 0 1 0 1 1 0
0 0 1 1	0 0 1 1 1 0 1
0 1 0 0	0 1 0 0 1 1 1
0 1 0 1	0 1 0 1 1 0 0
0 1 1 0	0 1 1 0 0 0 1
0 1 1 1	0 1 1 1 0 1 0
1 0 0 0	1 0 0 0 1 0 1
1 0 0 1	1 0 0 1 1 1 0
1 0 1 0	1 0 1 0 0 1 1
1 0 1 1	1 0 1 1 0 0 0
1 1 0 0	1 1 0 0 0 1 0
1 1 0 1	1 1 0 1 0 0 1
1 1 1 0	1 1 1 0 1 0 0
1 1 1 1	1 1 1 1 1 1 1

In this case to accommodate all the encoded watermark bits in the cover image additional pixels used are ¾ times the actual due to 3 check bits for every 4 bit message.

Repetition codes

Repetition codes are simplest type of linear block codes in which single message bit is encoded into a block of identical n bits, producing (n,1) block code. This type of code allows provision for a variable amount of redundancy and there are only two types of code words possible. The generator matrix of a (n,1) repetition code is (1Xn) vector G_{1Xn}=[11 1 1.....]. i.e. an all zeros code word or all ones code word[10].

In case of (3, 1) repetition code 1bit message is encoded into 3 bits by repeating same message bit. Similarly (5, 1) repetition code encodes 1bit message in to 5 bits by repeating same message bit.Table-III illustrates (3,1) and (5,1) repetition codes.

TABLE III. ENCODED DATA USING REPETITION CODES

Repetition code	Message bit	Encoded data
(3,1)	0	000
	1	111
(5,1)	0	00000
	1	11111

In case of (3, 1) repetition code the decoder takes block of 3 bits at a time and counts the number of 1's. If two or more bits are 1, then decoded bit is decided as 1. Otherwise, the decoder selects 0. So it can correct all patterns of one bit error. Similarly in (5, 1) repetition code, decoder takes 5 bits at a time and counts the number of 1's. If in the block of 5bits, three or more bits are 1, then the decoder selects 1 for the decoded bit. Otherwise, the decoder selects 0. So it can correct all patterns of two bit errors. The coding scheme is simple but the number of cover image pixels affected are 3 and 5 times respectively than without coding.

C. Salt and Pepper Noise attack

Noise is undesired information that contaminates the image. Digital Images corrupted by Salt and pepper noise often occur in practice, due to faulty memory locations in hardware, channel decoder damages, dyeing down of signal in communication links, multi path wireless communication, transmission in noisy channel etc. [8, 9].

Salt and Pepper noise will alter the pixel value to either minimal (0) or maximal (255) for 8-bit gray scale image. In this type, based on noise density, image pixel values are randomly changed to either 0 or 255. MATLAB command "imnoise" is used to generate salt and pepper noise of various densities.

V. PROPOSED SCHEME

The proposed scheme uses (3,1) and (5,1) repetition codes for encoding watermark image and performance is compared with watermark image encoding using (7,4) Hamming code.

A. Watermark Embedding and Extraction Algorithm

In this section we discuss the watermark embedding and extraction algorithm. 8-bit Grayscale .bmp image of size 256x256 is used as a cover image, a binary text patterned image of size 100x100 used as a watermark.

- **Using (7,4) Hamming code**

In this section watermark encoding using (7,4) Hamming codes, embedding and extraction process is discussed**.**

1. The watermark is scanned row wise. The watermark bit sequence is divided into block of 4-bits and encoded it into block of 7 bits as explained in section IV.
2. To embed the encoded watermark bit, the LSB of each of the cover image pixel is selected and replaced with each of the encoded watermark bit. The procedure is repeated until all the watermark bits are filled. Obtained image is watermarked

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image.

3. To extract the encoded watermark bits, LSBs of watermarked image pixels where watermark bits are embedded are collected. (7,4) decoding and correcting technique are applied to get back the extracted watermark bit sequence.

- **Using (3,1) and (5,1) Repetition code**

Watermark encoding scheme using Repetition codes, Embedding and Extraction algorithm is discussed.

1. Each bit is encoded into block of 3-bits using (3,1) repetition code. Same procedure is used in case of (5,1) repetition code except 1 bit is encoded in to 5-bits.

2. In embedding process using (3,1) repetition code LSB of three consecutive pixels of cover image are filled with corresponding single bit of watermark. For example first bit of watermark (0 or 1) is filled in LSB's of first three pixels of cover image next bit of watermark is filled in LSB of next three pixels of cover image etc. The procedure is repeated until all the bits are embedded. The image so obtained is called watermarked image. In case of encoding with (5,1) repetition code, blocks of five pixels of cover image are used and the five LSB's are filled with single bit of watermark image.

3. To extract the encoded watermark bits, in case of (3,1) repetition code, LSB bits from block of three watermarked image pixels are collected in the same order. Decoding process as explained earlier is applied to obtain extracted watermark. In case of (5,1) code block of 5 bits are considered.

VI. PERFORMANCE ANALYSIS

The perceptual quality between cover image and watermarked image is measured using SNR (signal to Noise Ratio) and MSE (Mean Square Error), as defined in (4) and (5) respectively. Larger SNR implies better quality of watermarked image. The SNR and MSE are defined below. For cover image,

$$\mathrm{SNR} = 10\log_{10}\frac{1/MN\,\sum_{x=1}^{M}\sum_{y=1}^{N}[C(x,y)]^2}{MSE} \tag{4}$$

Where C(x,y) is decimal value of 8-bit pixel at location (x,y) of cover image.

MSE is Mean square error and is given by

$$\mathrm{MSE} = 1/MN\sum_{x=1}^{M}\sum_{y=1}^{N}[C(x,y) - C'(x,y)]^2 \tag{5}$$

Where M, N is size of the cover image.

C'(x,y) is value of $(x,y)^{th}$ watermarked image pixel.

SNR and MSE as defined by (4) and (5) give a measure of perceptibility of watermarked image. Larger the value of SNR better the perceptibility. The SNR and MSE given in (4) and (5) correspond to cover image and watermarked image without any noise. The effect of noise on the extracted watermark can be studied by computing SNR of watermarked image and noisy watermarked image for different noise densities. In this case SNR is defined as

$$\mathrm{SNR} = 10\log_{10}\frac{1/MN\,\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)]^2}{MSE} \tag{6}$$

Where

$$\mathrm{MSE} = 1/MN\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)\text{-}I'(x,y)]^2 \tag{7}$$

And I(x,y) is value of $(x,y)^{th}$ watermarked image pixel.

I'(x,y) is value of $(x,y)^{th}$ noise added watermarked image pixel.

M, N is size of the watermarked image.

SNR and MSE as given by (6) and (7) give the effect of salt and pepper noise on watermarked image

Robustness between original watermark and extracted watermark is measured in terms of Bit Error Rate (BER) computed using (8) and Normalized Correlation (NC) computed using (9).

$$\mathrm{BER} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} W(i,j) \oplus W'(i,j)}{M.N} \tag{8}$$

Where W (i, j) is original watermark bit.

W' (i, j) is extracted watermark bit.

M, N is size of the watermark.

$\oplus$ is Bit by bit modulo-2 addition (logical XOR)

For computing Normalized Correlation(NC) binary 0 is regarded as -1 and is given by

$$\mathrm{NC} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} W(i,j).W'(i,j)}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N} W(i,j)\wedge 2}\ \sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N} W'(i,j)\wedge 2}} \tag{9}$$

BER and NC values are generally 0 to 1. Ideally BER should be 0 and NC should be 1. Performance of proposed scheme is investigated using 256X256 pixels 8-bit gray scale cover image "lena.bmp " and binary text patterned watermark of size 100X100 bits. They are shown in the Fig. 2a and Fig. 2b respectively. The effect of watermark in cover image and watermark immunity against salt and pepper noise for four different cases

Case1. Without coding.

Case2. With (7,4) Hamming code.

Case3. With (3,1) repetition code.

Case4. With (5,1) repetition code are investigated

The total number of cover image pixels used to embed the watermark and SNR of watermarked image computed using (4) for all four cases without considering the salt and pepper noise are given in table IV. In 1st case total numbers of watermark bits are 10000 so 10000 cover image pixels are used to embed all the bits. Case2 uses (7,4) Hamming codes so (7/4)(10000)=17,500 pixels are used to accommodate all the bits. Similarly case3 and case4 (3,1) and (5,1) repetition codes are used so 3X10000=30000 and 5X10000=50000 cover image pixels are used respectively in embedding process. It is shown in table IV that increase in watermark bits increases the cover image pixels affected and hence reduces the SNR of watermarked image. Even though there is reduction in SNR, visual quality of the watermarked image is still acceptable in all the cases as shown in Fig. 3. For all the four cases mentioned above the BER in extracted watermark and NC between original and extracted watermark for different noise density of salt and pepper noise are computed and given in table V and VI respectively. A Plot of BER vs. Noise density and NC vs. Noise density are given in Fig. 5 and Fig. 6 respectively. In table V BER '0' indicates original and extracted watermark are identical. Similarly in table VI NC value '1' indicates extracted watermark is same as original watermark. It is also observed in

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table V &VI and Fig. 4 & Fig. 5 that as noise density increases, (5,1) repetition code provides highest NC and minimal BER compared to other three cases. SNR of noisy watermarked image and MSE between watermarked image and noisy watermarked image for different noise density are computed using (7) and (8) respectively and given in table VII and VIII. For the four cases as noise density increases more number of watermarked pixels are affected by salt and pepper noise this in turn affects the watermark. Effect of noise on watermarked image with noise density 0.4 for four different cases are given in Fig. 4 Table IX is pictorial comparison of extracted watermark with different noise density values of four different cases. It is seen that for all the 4 cases if NC is greater than 0.75 the extracted watermark is legible. For noise density 0.4, (5,1) provides high perceptual quality compared to other three cases. Comparing the four schemes it is seen that schemes employing encoding of watermark image exhibits better robustness than without encoding, in the presence of salt and pepper noise amongst the schemes employing encoding, (7,4) Hamming code is capable of correcting single error in a block of 7 bits. The number of pixels of cover image used for embedding encoded watermark is 17500 which is less compared to 30000 as in case of (3,1) repetition code or 50000 as in case of (5,1) repetition code. In case of (7,4) Hamming code the watermarked image perceptibility is highest since compared to (3,1) or (5,1) repetition code least number of cover image pixels are used for embedding. Even though perceptibility is good robustness is poor. In case of (5,1) repetition code the watermarked image perceptibility even though not as good as in the case of (7,4) Hamming code, it is still perceptible. The scheme is more robust compared to the other three schemes discussed. Thus with marginal reduction in perceptibility of watermarked image it is possible to achieve better robustness in the presence of salt and pepper noise.

TABLE IV. TOTAL NUMBER OF COVER IMAGE PIXELS

Case	Watermark encoding Scheme used	Total no of pixels used	SNR of watermarked image in dB
1	Without encoding	10,000	53.6582
2	(7,4)hamming code	17500	51.2147
3	(3,1)repetition code	30000	48.878
4	(5,1)repetition code	50000	46.6788

Figure 2a

Figure 2b

Figure 2a. 256X256 gray scale cover image lena.bmp
Figure 2b. 100X100 binary text patterned watermark

Figure a Figure b Figure c Figure d

Figure 3. Perceptibility measure of watermarked image for a. Without encoding b. with (7,4) Hamming code. c. (3,1) repetition code d. (5,1) repetition code

TABLE V. BIT ERROR RATE IN EXTRACTED WATERMARK IN PRESENCE OF SALT AND PEPPER NOISE

Noise density	Case1	Case2	Case3	Case4
0	0	0	0	0
0.01	0.0066	2e-04	0	0
0.1	0.0497	0.0186	0.0075	0.0012
0.2	0.0993	0.0664	0.0252	0.0082
0.25	0.1222	0.0980	0.0433	0.0150
0.3	0.1520	0.1225	0.0587	0.0259
0.4	0.1997	0.1944	.1019	0.0626
0.5	0.2534	0.2614	0.1572	0.1011
0.8	0.4022	0.4190	0.3685	0.3218

TABLE VI. NORMALIZED CORRELATION BETWEEN ORIGINAL WATERMARK AND EXTRACTED WATERMARK IN PRESENCE OF SALT AND PEPPER NOISE

Noise density	Case 1	Case 2	Case 3	Case 4
0	1	1	1	1
0.01	0.9904	0.9994	1	1
0.1	0.9052	0.9562	0.987	0.997
0.2	0.797	0.8736	0.9398	0.9832
0.25	0.7552	0.8090	0.9152	96.90
0.3	0.7004	0.7432	0.8752	0.9478
0.4	0.601	0.6162	0.8002	0.8894
0.5	0.4966	0.4818	0.685	0.793
0.8	0.1934	0.1762	0.2794	0.3788

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TABLE VII. MSE BETWEEN WATERMARKED IMAGE AND SALT AND PEPPER NOISE ADDED WATERMARKED IMAGE

Noise density	Case 1	Case 2	Case 3	Case 4
0.01	189.9197	173.4075	187.0653	180.8729
0.1	1.8331e+3	1.8527e+3	1.8520e+3	1.81010E+3
0.2	3.6385e+3	3.6496e+3	3.6195e+3	3.64901E+3
0.25	4.5571e+3	4.5731e+3	4.5539e+3	4.5910e+3
0.3	5.4366e+3	5.4816e+3	5.4849e+3	5.48412E+3
0.4	7.2951e+3	7.3659e+3	7.3049e+3	7.34793E+3
0.5	9.2258e+3	9.1625e+3	9.1278e+3	9.11165E+3
0.8	1.4576e+4	1.4686e+4	1.4612e+4	1.4607e+4

TABLE VIII. SNR IN DB OF NOISY WATERMARKED IMAGE FOR DIFFERENT NOISE DENSITY

Noise density	Case 1	Case 2	Case 3	Case 4
0.01	19.7623	20.0896	20.0954	19.9177
0.1	9.8562	9.8023	9.8661	9.914365
0.2	6.8686	6.8579	6.8819	6.869641
0.25	5.8909	5.8782	5.8636	5.8723
0.3	5.1245	5.0912	5.0935	5.100321
0.4	3.8475	3.8081	3.8491	3.829739
0.5	2.8278	2.8602	2.8816	2.895422
0.8	0.8414	0.8112	0.8382	0.8458

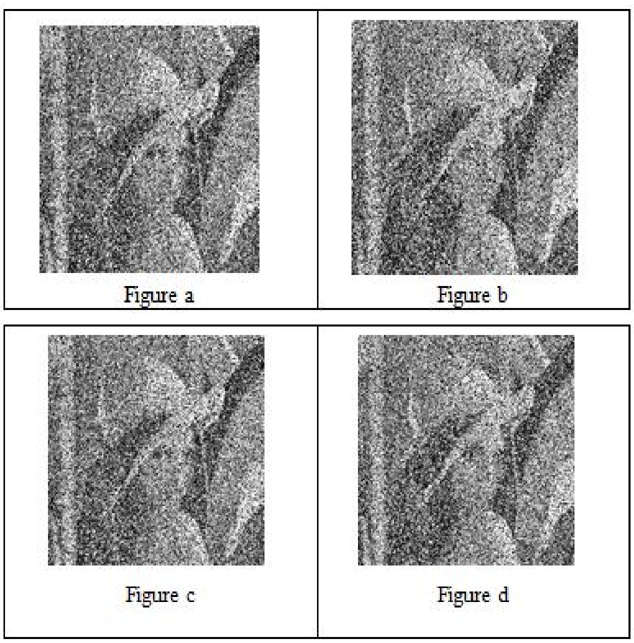

Figure 4. watermarked image in presence of salt and pepper noise with noise density 0.4 for a. without coding b. with (7,4) hamming code c.(3,1) repetition code d. (3,1) repetition code

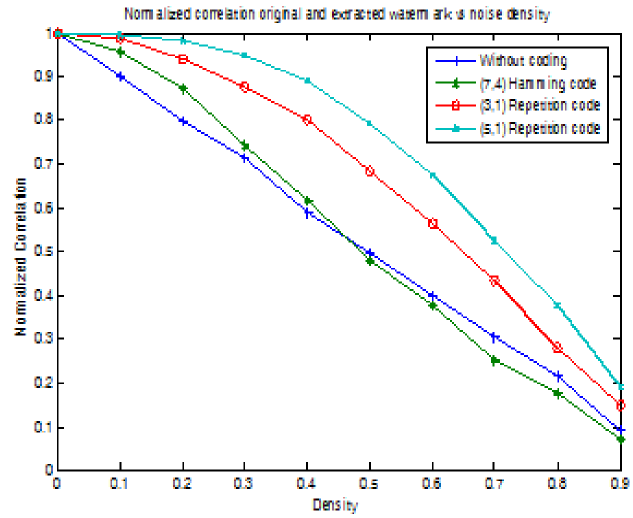

Figure 5. Plot of Normalized Correlation between original and extracted watermark in presence of salt and pepper noise with different noise density

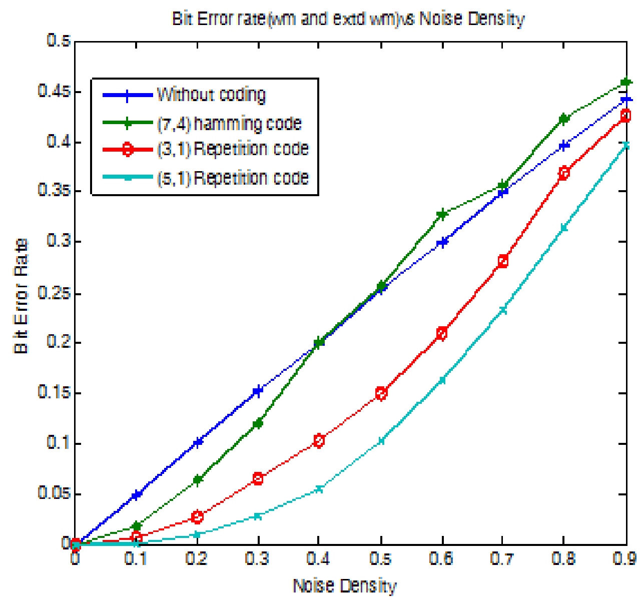

Figure 6. Plot of Bit Error Rate in extracted watermark in presence of Salt and Pepper noise with different Noise Density

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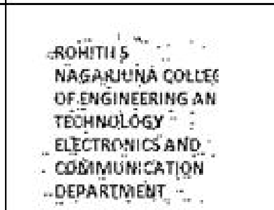
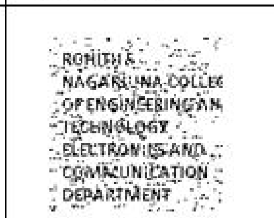
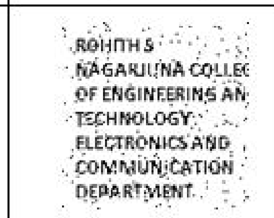
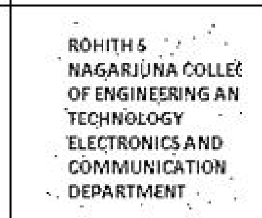
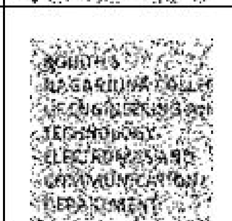
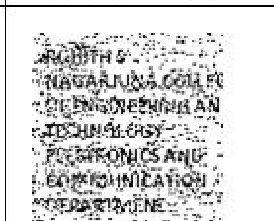
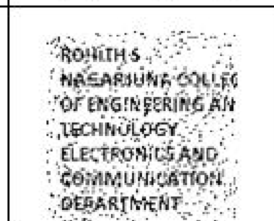
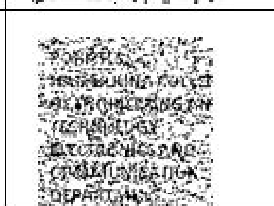
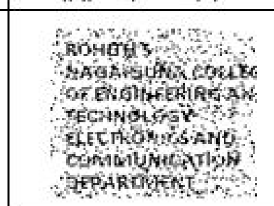
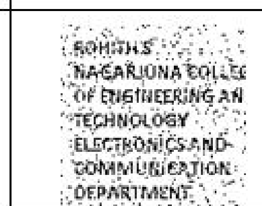
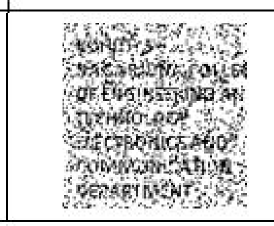
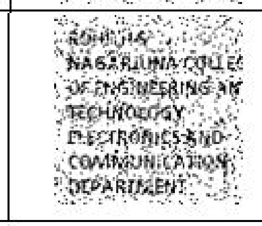
TABLE IX. PICTORIAL COMPARISON OF EXTRACTED WATERMARK WITH DIFFERENT NOISE DENSITY OF SALT AND PEPPER NOISE

Noise density	Without Coding	(7,4) Hamming code	(3,1) Repetition code	(5,1)Repetation code
0.01				
0.1				
0.2				
0.3				
0.4				
0.5				

VII. CONCLUSION

This paper discusses a simple, robust LSB watermarking scheme against salt and pepper noise using repetition code. In this scheme watermark is encoded by (5,1) repetition code and embedding using LSB Technique. This scheme is tested with Salt and Pepper noise for different noise density values and compared with embedding encoded watermark using (7,4)Hamming code, (3,1) repetition code and without encoding. The experimental results and tabulation show that scheme is simple and robust against Salt and Pepper Noise with different noise density. Using this scheme extracted watermark up to 0.4 noise density can be easily identified. Computational complexity of watermark encoding and decoding using repetition codes is simple compared to (7,4) Hamming codes. So processing speed of the algorithm will increase. This algorithm is more suitable in noisy channels and storage where watermark robustness against salt and pepper noise is needed. From Fig. 5 it is seen that for a given noise density NC is more and BER is less in case of (5,1) repetition code compared to (3,1) repetition code. Higher the ‘n’, better the immunity against noise as seen in table IX. However perceptibility decreases with increases in n. this is because of large number of pixels of cover image are affected in embedding watermark bits. At higher noise densities n has to be increased to obtain robustness but perceptual quality of the watermarked image or SNR will decrease.

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